

The two consecutive paragraphs beginning on Page 1, line 14:

Such measuring heads are, for example, to be used to calibrate ~~toque~~ torque wrenches. The sensor means, conventionally, have strain gages. These strain gages are cemented to parts which are deformed by the torque to be measured. Such strain gages provide weak, analog signals. Usually, these analog signals are not exactly proportional to the torque exerted on the torque sensor. Therefore, signal processing is necessary to obtain a signal which exactly represents the torque. This signal is displayed by display means or is otherwise supplied to evaluation means, for example, for determining the variation in time or the statistical distribution of the torques.

Each torque sensor has a limited measuring range, in which it operates optimally. Therefore, different measuring heads with correspondingly different torque sensors are provided. These different measuring heads are connected to the display or evaluation means ~~ore~~ or are applied thereto through a selector switch.

The two consecutive paragraphs beginning on Page 2, line 25:

Thus, the invention provides a plurality of measuring heads, which either may have different measuring ranges or may be adapted to different tools to be tested. Each of these measuring heads has its own signal processing means. The signal processing means are calibrated in the same way, such that the torque measuring data of different measuring heads can be compared with each other. A certain torque  $T$  acting on one measuring head provides the same torque data at the measuring head signal output of this measuring head as the torque  $T$  would provide at the measuring head signal output of another

measuring head. 1 Nm (Newton meter) at one measuring head would provide also 1 Nm at the other measuring head. When calibrating a measuring head, the individual signal processing means can also be adjusted to take individual non-linearities of the torque sensors into account. The measuring heads can then simply be connected in parallel with the display or evaluation means. If a torque is exerted on ~~anyone~~ any one of the measuring heads, this torque will automatically be displayed or evaluated with the correct calibration. ~~Though the~~ The use of individual signal processing means in each measuring head represents an additional expenditure. This expenditure is, however, largely compensated for by saving expensive measures for shielding or suppression of ~~interferences~~ interferences and by saving selector switch means. The invention offers the advantage of simplified handling and reduction of the risk of operational errors.

Preferably, the signal processing means comprise an A/D-converter for converting analog signals of the torque sensor into digital data, these digital data, after further digital signal processing, if necessary, appearing at the measuring head signal output. The digital data permit largely undisturbed transmission also to remote display or evaluation means. In particular, means can be provided for the wireless transmission of data appearing at the measuring head signal output to the display or evaluation means ~~may be provided~~.

The six consecutive paragraphs beginning on Page 4, line 4:

Fig.\_1 is a schematic-perspective illustration and shows a torque sensor, to which a printed circuit board carrying signal processing means is attached.

Fig.\_2 is an exploded, schematic-perspective view similar to Fig.\_1.

- Fig.\_3 is a schematic illustration of a testing device having a plurality of measuring heads and one single display device common to all measuring heads.
- Fig.\_4 is a schematic illustration similar to Fig.\_3 of a testing device having display and evaluating means.
- Fig.\_5 is a schematic illustration similar to Fig.\_3 and 4 and shows a testing device wherein a computer with screen is provided for display and evaluation.
- Fig.\_6 is a block diagram of the signal processing means.

The four consecutive paragraphs beginning on Page 4, line 22:

Referring to Figs.\_1 and 2, numeral 10 generally designates a torque sensor. As can be seen best from Fig.\_2, the torque sensor 10 comprises an outer annular body 12 and an inner annular body 14. Outer and inner annular bodies 12 and 14, respectively, are interconnected by radial webs 16 and 18. The webs 16 have relatively large width in circumferential direction but have relatively small axial dimensions. The axial dimensions of the webs 16 are substantially smaller than the axial thickness of the outer annular body 12. The webs 18 are narrow in circumferential direction but extend, in axial direction, through nearly the whole thickness of the outer annular body. Wide and narrow webs 16 and 18, respectively, alternate. The webs 16 and 18 are arranged in regular arrangement with an angular offset of  $45^{\circ}$  between each pair of neighboring webs 16 and 18, whereby a cross of four wide webs 16 is formed, which are angularly spaced by  $90^{\circ}$ . The wide webs 18 carry strain gages 20, which are arranged in a bridge circuit.

Such a torque sensor is described in DE 202 09 650 U1, the contents of which is incorporated herein by reference. A driving part 24 is affixed in the central aperture 22 of the inner annular body 14. A tool (not shown) can engage this driving part 24 to exert the torque to be measured.

The front face, as viewed in Fig. 2, of the inner annular body 14 and the front faces of the webs 16 and 18 lie in one plane which is offset to the inside relative to the plane of the front face of the outer annular body. In this way, a shallow cavity is defined within the outer annular body and in front of the inner annular body 14. A printed circuit board 26 is retained in this cavity. The printed circuit board 26 is attached to the inner annular body 14 by screws 28. To this end, the printed circuit board 26 has screw holes 30. The screws 28 pass through the screw holes 30 and spacers 32 and are screwed into threaded bores 34 of the inner annular body 14. Thereby, the printed circuit board 26 is held at a distance from the inner annular body 14 and the webs 16 and 18. The printed circuit board 26 carries, on its backside facing the annular body 14, the components of the signal processing means schematically indicated in dashed lines in Figs. 1 and 2. The signal processing means are generally designated by 36 in Figs. 1 and 2.

The signal processing means 36 are illustrated in Fig. 6. Referring to Fig. 6, the measuring pick-up 42 and the analog portion of the signal processing means 36 are shown on the left of the line 40, and the digital portion of the signal processing means is shown on the right of the line 40. The measuring pick-up 42 is a bridge circuit of strain gages 44. The strain gages 44 are cemented on the wide webs 16. When a torque is exerted, the strain gages will be stressed by shearing action. Thereby, they change their resistances. The strain gages 44 in the bridge circuit 42 provide a weak analog signal. This analog signal is applied to an integrated circuit 46. The integrated circuit 46 is mounted on the backside of the printed circuit board 26. There are short transmission paths between the measuring pick-up 42 and the integrated circuit 46. Thereby, interferences are minimized. The integrated circuit 46 is a combination of pre-

amplifier and A/D-converter. The pre-amplifier raises the weak analog signal to the level required for the A/D-conversion. The A/D-converter generates digital measuring data representing the analog signal. These digital measuring data are applied to an integrated circuit 50 through a bus 48. The integrated circuit 50 converts the measuring data on the bus 48 to a digital signal, which represents the exerted torque in Nm or mNm. The integrated circuit compensates for zero offset and non-linearities. In addition, an adjustment for calibration can be effected. Then, at a measuring head signal output 52, a digital signal is obtained, which directly represents the torque in Nm or mNm.

The paragraph beginning on Page 6, line 9:

Fig.\_3 illustrates a testing device having three measuring heads 54, 56 and 58 of the type described above and two torque wrenches 60 and 62, each of which also has a torque sensor with signal processing means in accordance with Fig.\_6. In the measuring heads 54, 56 and 58, the respective outer annular body 12 of the torque sensor 10 is fixedly retained in a stationary housing 64, 66 and 68, respectively. The measuring heads 54, 56, 58 and torque wrenches 60 and 62 are all connected directly, i.e. without further signal processing, ~~im in~~ parallel with a display device 70. The digital measuring data of the torque wrench 60 are applied in wireless form. This is indicated by the dotted connection 72. The display device 70 is connected with a receiver 74. Also this should be covered by the term “directly”.

The three consecutive paragraphs beginning on Page 7, line 10:

Fig.\_4 is substantially identical with Fig.\_3 described above. Corresponding elements bear the same reference numerals as in Fig.\_3.

In the embodiment of Fig. 4, a computer 78 such as a laptop is provided in addition to the simple display device 70. The respective digital torque measuring signal applied to the display device 70 is applied also to this computer 78 through a data line 80 and a level converter 82. The computer 78 represents evaluating means for evaluating the measured torques. Thus, the computer 78 may, for example, track the variation in time of a torque exerted through a torque wrench and may detect the position of a kink in the torque-versus-time characteristic appearing, when the torque wrench is released. The torque measuring data may also be collected and evaluated statistically.

Fig. 5 also is similar to Figs. 3 and 4. Corresponding elements, again, bear the same reference numerals as in Figs. 3 and 4. No display device is provided, in the testing device of Fig. 5, but a computer only. All measuring head signal outputs 52A, 52B, 52C and the outputs of the torquers 60 and 62 are applied to the computer 78 through level converter 82. The screen of the computer 78 fulfills the function of the display device 70.

1. (Currently Amended) A testing device for ~~measuring torques~~ testing torque wrenches, comprising a plurality of measuring heads having different functional characteristics, each of said measuring heads having a driving part means for engagement by a torque wrench to be tested and permitting a torque to be exerted thereon through said torque wrench, a torque sensor means for providing a sensor signal indicative of said exerted torque, and separate signal processing means for processing said sensor signals from said torque sensor to provide torque measuring data at a measuring head signal output, each of said signal processing means being located in the associated one of said measuring heads in close proximity with said torque sensor, said signal processing means of said plurality of measuring heads being calibrated to provide, at ~~anyone~~ any one of the said measuring head outputs, the same torque measuring data, when the same torque is exerted upon the respective one of said measuring heads, the measuring head outputs of said plurality of measuring heads being applied directly, in parallel, to display or evaluation means.
2. (Cancelled) A testing device as claimed in claim 1, wherein at least some of said measuring head are different.
3. (Currently Amended) A testing device as claimed in claim 2 1, wherein at least some of said measuring heads have different measuring ranges.
4. (Original) A testing device as claimed in claim 1, wherein, in at least one of said measuring heads, said signal processing means comprise means for determining the maximum torque of a torque pulse exerted on said measuring head.
5. (Original) A testing device as claimed in claim 1, wherein said torque sensor provides analog output signals, and said signal processing means comprise A/D-converter means for converting said analog signals into digital signals.

6. (Original) A testing device as claimed in claim 5, wherein said signal processing means further comprise means for linearizing and calibrating said digital signals from said A/D-converter to provide said torque measuring data.
7. (Currently Amended) A testing device as claimed in claim 5, and further comprising means for wireless transmission of said torque measuring data appearing at said measuring head output to said ~~diplay~~ display or evaluation means.
8. (Cancelled) A testing device as claimed n claim 1, wherein at least one of said measuring heads forms part of a torque wrench.
9. (Currently Amended) A testing device as claimed in claim 1, wherein

at least one of said measuring heads comprises a stationary housing, said torque sensor comprising an outer annular body fixedly retained in said housing, an inner annular body connected with said outer annular body through webs, a driving part permitting exerting of a torque thereon and attached to said inner annular body, and measuring pick-up means responding to deformation of said webs under the action of said torque,

said signal processing means comprise a printed circuit board, on which components of said signal processing means are mounted, said printed circuit board having a central aperture therethrough, said printed circuit board having a central aperture therethrough, said printed circuit board being arranged in a shallow cavity within said outer annular body and above said inner annular body and said webs and being attached to said inner annular body, and

said driving part means extends through said central aperture of said printed circuit board.